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# TECHNOLOGY ASSESSMENT OF FUTURE INTERCITY PASSENGER TRANSPORTATION SYSTEMS

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TECHNOLOGY ASSESSMENT OF FUTURE INTERCITY  
PASSENGER TRANSPORTATION SYSTEMS

VOLUME 6

IMPACT ASSESSMENT

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IMPACT ASSESSMENT

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As is true of most of the activities conducted in this study, the impact assessment work was very much a team effort. It is fitting that principal contributors be identified.

The essential structure of the assessment methodology was articulated originally by William L. Garrison, with significant input from Aaron Gellman. Identification of impacts was pursued by a multidisciplinary "Impact Team," under the overall direction of Dr. Garrison. In its work, the Impact Team received noteworthy assistance from several colleagues in California government, particularly Arthur Bauer of the State Senate Office of Research and Gordon Hutchings of the California Department of Transportation, Division of Transportation Planning. The contributions of these individuals are gratefully acknowledged.

# IMPACT ASSESSMENT

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## SUMMARY

### Introduction

This report describes consequences that might occur if certain technological developments take place in intercity transportation. These consequences are broad ranging, and include economic, environmental, social, institutional, energy-related, and transportation service implications. The possible consequences are traced through direct (primary) impacts to indirect (secondary, tertiary, etc.) impacts. Chains of consequences are traced, reaching as far beyond the original transportation cause as is necessary to identify all impacts felt to be influenced significantly by the technological development considered.

The consequences that are described here are not predictions as such. The technological innovations considered may or may not happen, and, if they do, the impacts described will not necessarily occur. The primary purpose of this exercise is to expand awareness of the possible implications of technologies in order to permit society to prepare for and control these effects. Thus, the statements made here only describe what *might* occur *if* certain technological developments take place, and the likelihood of these occurrences is not a key consideration in this report. Clearly, additional work should be undertaken to look more deeply into the nature and likelihood of the most important impacts identified.

Technologies. The future transportation technologies considered are the following:

- The evolving fleet of increasingly fuel-efficient and quieter conventional takeoff and landing (CTOL) subsonic aircraft, varying in size from less than 70 to more than 600 seats
- Short and vertical takeoff and landing (STOL/VTOL) aircraft
- American commercial supersonic transport (SST) aircraft
- Improved intercity buses
- Improved variations of combustion engine automobiles, including alternatives to the gasoline-fueled internal combustion engine
- Electric automobiles, with optional power pickup from electrified highways
- Dual mode automobiles, trucks, and buses; that is, vehicles able to operate without direct driver control on automated highways

- Improved passenger trains (IPT)
- Very high-speed ground transportation (VHS GT) systems, with vehicles operating on dedicated guideways at speeds of 250 to 400 mph.

In addition, attention is given to possible innovations in vehicle rental, access to and egress from intercity transportation, intermodal transfer facilities, and passenger information systems.

Assessment Methodology. The assessment of possible impacts of future intercity transportation technologies was undertaken through a systematic analysis approached from several directions. These directions are reflected in the following questions that were asked concerning the impacts of transportation developments.

- How does the impact affect the development and use of economic, natural, and human resources; the nature of the environment and settlement patterns; the life-styles, values, and well-being of individuals; and the evolution and behaviour of political, social, and economic institutions?
- When does the impact occur in the life cycle of the technology? Is it during its invention, promotion, and development; its implementation; its operation; or its revision, replacement, or abandonment?
- How does the strength of the impact change with time?
- Under what political, economic and social conditions, and physical settings is the impact felt most strongly, and do changes in background conditions affect the nature of the impact? How might the impact change with changes in the conditions and setting in which it occurs?
- What are likely to be society's responses to the impact and how might these responses change the nature of the impact and give rise to additional indirect impacts?

The above questions were asked repeatedly in trying to trace the chains of consequence associated with technology development options. Some of the main findings are summarized below.

#### Impact Highlights

Aircraft. Low density routes are inherently more costly than high density routes. Whether small capacity, short-range aircraft can be developed with economics sufficiently attractive to air carriers remains a major question. This, and a variety of related considerations suggest

that the small commercial aircraft market will not be attractive to manufacturers for some time. However, if small commercial aircraft do become widespread, significant impacts to be anticipated include possible effects on general aviation traffic growth and operations, and increased crowding at major hub airports.

For a variety of reasons, widebody aircraft cannot be expected to compensate for airport airside capacity deficiencies to the extent once hoped. Continuing demand for schedule frequency and more convenient ground access, plus relaxed regulatory restraints on charter services will probably increase the use of satellite airports in major metropolitan areas, although with little relief to congestion at major hub airports.

One of the major current and future causes of airport congestion is the competing airlines' practice of scheduling similar aircraft on the same routes at nearly the same time. Prohibition of this practice is a possible future regulatory response to worsening airside congestion at major hub airports. Another possibility is adoption of the cartel system practiced in Europe and elsewhere.

Since STOL/VTOL aircraft are inherently more costly than CTOL aircraft of the same generation, for the foreseeable future the market for STOL/VTOL service would be limited to business and well-to-do travelers with very high values of time. Other segments of the population would be expected to resist strongly the environmental intrusion threatened by introduction of this new service into their communities.

While serious environmental and economic (especially fuel consumption) considerations stand squarely in the path of developing an American SST, another less visible but formidable barrier is the lack of political constituency of this technology, stemming partially from its image as a technology for the rich. However, despite such difficulties, it seems possible that development of an American SST could be pursued later in this century, if backed by private capital, and if prospects for reducing operating costs and environmental impacts appear favorable.

Buses. Buses are the lowest cost and most energy efficient form of common carrier intercity passenger transportation. This mode now has a variety of adverse features, both physical and psychological, that prevent full exploitation of its advantages; but many of these problems seem amenable to technological and institutional action in the future, perhaps with dramatic implications for the role of bus in future intercity transportation.

The small size of the new bus market, and other factors, seems to inhibit innovation in bus technology. Perhaps, here, government can best stimulate innovation through publicly sponsored research and through its role as a consumer by creating new, low risk markets for innovative bus technology.

Automobiles. Automobiles account for about 85% of intercity travel. The many desirable service features of this mode strongly suggest that the personal automobile in one technological form or another will be the dominant form of intercity travel for the foreseeable future. The overwhelming importance of the automobile in American society and the high visibility of its impacts suggest that technological change in automobiles will occur at a rapid pace during the next several decades, bringing a host of profound environmental, economic, and social consequences.

While considerable improvements in the air pollution and fuel consumption characteristics of gasoline-fueled internal combustion engines will occur in the next decade, full achievement of current environmental and energy goals may require transition to another engine technology before the 1990s. In the very long term, converting automobile transportation to an inexhaustible, nonpolluting energy source may lead to widespread use of electric autos, operating on electrified highways, employing energy generated by nuclear fusion, solar power, and similar sources. Among the impacts of introducing new automobile propulsion technologies are the costs and labor retraining impacts incurred by service stations and the automobile maintenance and repair industries, major dislocation in the energy supply industry, possible mobility limitations on owners of obsolete automobiles late in the transition period, increased demand for and possible shortages of scarce materials, the major costs and environmental effects of highway construction and revision, a need for new highway funding mechanisms, difficulties in vehicle recycling due to new materials, and safety problems due to increased heterogeneity of the vehicle fleet.

On several counts, the long-term prospects seem favorable for introduction of automated highways and of dual-mode vehicles that can operate under either automated or nonautomated control. Important impacts to be anticipated for this technological development are the large capital costs required for highway construction and revision; the need for stringently controlled vehicle repair and maintenance practices to ensure fail-safe operation in the automatic mode, perhaps leading to increased centralization and automation in this industry; increased and possibly total reliance on rental for dual-mode vehicle supply, again to ensure vehicle reliability; possible emergence of a new form of intra-community private vehicle as a less expensive, local service alternative to rented dual-mode vehicles; increased population dispersal in a nucleated settlement pattern, with increased social stratification; and improved transportation service to nondrivers through central computer control of driverless automated vehicles, this possibly leading to computer surveillance of all individual intercity travel.

High-Speed Ground Transportation. A possible result of government efforts to promote use of improved passenger trains or very high-speed ground transportation systems in dense travel corridors could be the restriction of short-haul air service wherever there has been a large

public investment in high-speed ground. This policy could significantly alleviate congestion at several major airports; however, mobility of many travelers would certainly decrease, possibly giving rise to significant population and employment relocations within the affected corridors in the long term.

Opposition to improved passenger rail transportation may arise from the rail freight industry, due to perceived interference with freight operations, and from the general public, on grounds that the system benefits mainly the suburban rich and business travelers. Also, major public investments in improved rail may discourage private sector investment in competing bus and short-haul air technologies.

The environmental costs of very high-speed ground transportation systems, particularly noise and neighborhood disruption, certain safety considerations, plus probable community resistance to the new system suggest that any future VHSCT guideway will have to be isolated from its environment, most probably through tunneling. Also, operating costs of an unisolated system, including high energy consumption, would probably be excessive. With current construction methods, the tunneling costs for such a system would probably be prohibitive.

Conventional VHSCT concepts require large distances between stations in order to achieve high average speeds. This seriously reduces traveler access to the system and, thus, reduces potential patronage. Such considerations suggest that alternate VHSCT concepts should be considered, including network structures that permit skipping intermediate stops, as well as moving rendezvous techniques. The financial and operational feasibility of such concepts are questionable, however.

General Considerations. Financial resources alone probably do not completely eliminate any technology considered in this study from being implemented within the next 25 to 50 years. However, new funding mechanisms, particularly for ground transportation, will be required.

Difficulty of access to and egress from intercity transportation, and of transferring between modes, will probably continue to be the weakest link in intercity public transportation for some time. No solution is in sight. The problem is essentially local and institutional. Nationally designed, sweeping solutions would probably cause more financial and institutional problems than they would solve. One facet of the access/egress and transfer problem is the lack of adequate information available to travelers. Information deficiencies may be resolved partially by means of a federally coordinated traveler information system, but this proposal has significant serious problems with respect to cost allocation, responsibility for data management, as well as potential loss of local control over local transport and threats to individual privacy.

Future advances in telecommunications may eliminate the need for certain types of transportation. Initially, new communications technology will primarily replace transport of documents and records; but, eventually, restructuring of commercial activities may somewhat reduce business travel. These changes may induce considerable population dispersal, increasing the future need for low density, high quality transportation, such as automated highways and small commercial aircraft.

The land use patterns that exist 50 years in the future will be affected significantly by the transportation systems that evolve in the interim (just as today's patterns are strongly determined by the transportation technology changes of the past half century). While the locational implications of the different technologies are fairly subtle, in the long run these forces are powerful and should be weighed carefully in decisions regarding major transportation research and investment programs.

Care must be taken to avoid the major economic losses that may occur due to the erratic public funding to which certain intercity transportation modes, such as VHSCT, are particularly vulnerable. Other incremental transportation technologies, such as electrified and automated highways and improved CTOL, are not as vulnerable to unanticipated fluctuations in public financial support.

In planning future intercity transportation technological development, certain technologies, because of high initial capital costs or perceived unrecoverable social benefits, are treated as "public commodities," and receive government funding for technology development, construction, and in some cases, operation. This state of affairs creates the potential problem that the separate tasks of technology promotion and technology evaluation can become intertwined, with the result that the government-supported technology may gain undue advantage over technologies able to function in the private sector.

Finally, the different intercity transportation technologies have varying implications for foreign trade and the U.S. balance of payments. Certain technologies, such as improved conventional aircraft, an American SST, and improved automobiles, would probably have worldwide markets. Others, such as small CTOL, may be particularly attractive to developing countries. Still others, such as VHSCT and automated highways, might have rather limited potential for export as whole systems, but individual components might become valuable export commodities.

### Conclusion

This technology assessment is viewed as the first step in coming to grips with many of the important possible implications of future intercity transportation technologies. This study does not attempt to solve any of the potential problems described; it simply tries to place the technologies and their consequences in a long range and broadly based

perspective. From this perspective, it should be possible to design systematic research and technology development programs to define more precisely and control these impacts in an efficient and timely manner.

## I. INTRODUCTION

This technology assessment identifies a wide range of economic, environmental, institutional, political, and social consequences associated with different future intercity transportation developments. These consequences extend beyond the immediate users and suppliers of intercity transportation and include effects upon the whole of society: its life-styles and institutions, its political and philosophical tenets, the production and allocation of its resources, and the basic human condition.

In trying to assess as large a group of technologies as may appear in the next 25 to 50 years of intercity transportation, the most important objective is to identify as many pertinent impacts as possible. The flushing out of the details of these impacts is left to be pursued in more narrowly focused follow-on studies.

The direct (primary) and indirect (secondary, tertiary, etc.) impacts identified in this assessment are seen as strongly influenced by the development and exploitation of the transportation technologies described. Furthermore, these impacts are expected to emerge according to the particular linkages identified. On the other hand, few of the impacts identified in this report are felt to be inevitable. Considerable uncertainty exists both in the prospects for the technologies themselves and in the nature of their anticipated impacts. Furthermore, many impacts are based upon assumed background settings, which may never occur. However, such speculation is appropriate since the object of technology assessment is not to predict what will be, but to anticipate and help prepare for what might be.

### Methodology

A multidimensional approach is used to uncover the chains of consequences associated with the possible future intercity transportation technologies considered. A categorization of impact types and incidence of impacts is not by itself sufficient, in part because a rigid categorization does not deal adequately with the many uncertainties involved. These include uncertainties about the characteristics of the technologies; uncertainties about underlying political, social, and economic conditions; and uncertainties concerning the manner in which the impacts might unfold. Furthermore, the consequences which must be dealt with are multilevel and generally not linear; rather, direct consequences lead to other indirect consequences, which, in turn, contain branches and loops which frustrate attempts to describe all impacts within a simple categorization.

The impact analysis is documented in this report in a mixed narrative and graphical style. The style allows flexibility in dealing with intricate causal structures and uncertainties. Procedural discipline is exercised

to ensure that the coverage of impacts is as thorough as possible. The specifics of this discipline are described below.

Technologies. A large number of possible future intercity transportation technologies are considered, with guidance obtained from the technology screening reported in Volume 3. Given the myriad of technical variations, the analysis is restricted to families of possible future technologies. Consideration, for example, is given to the family of improved combustion engine automobiles, with little distinction among improved gasoline-fueled internal combustion engines, diesels, gas turbines, Stirling engines, and so forth.

The technologies considered in the analysis are:

AIRCRAFT      The evolving fleet of increasingly fuel-efficient and quieter conventional takeoff and landing (CTOL) subsonic aircraft, varying in size from less than 70 to more than 600 seats

Short and vertical takeoff and landing (STOL/VTOL) aircraft

An American commercial supersonic transport (SST) aircraft

HIGHWAY      Improved intercity buses

Improved versions of combustion engine automobiles, including alternatives to the gasoline-fueled internal combustion engine

Electric automobiles, with optional power pickup from electrified highways

Dual-mode automobiles, trucks, and buses; that is, vehicles able to operate without direct driver control on specialized automated highways

FIXED GUIDE-      Improved passenger trains (IPT)

WAY

Very high-speed ground transportation (VHS GT) systems with vehicles operating on dedicated guideways at speeds over 250 mph.

In addition, attention is given to the consequences of possible innovations in vehicle rental, access to and egress from intercity transportation, intermodal transfer facilities, and passenger information systems.

Categories of Impacts. The impact analysis begins with a direct classification of consequences into major categories. Initially, a rather large number of impact categories and classes of affected persons and institutions were identified, but further consideration suggested that impacts could be classified within four essential categories.

1. Impacts associated with development and use of resources. Consequences include both domestic and international economic developments; the accumulation of personal and corporate wealth; public, corporate, and personal expenditures; development and use of the labor pool; development and use of energy and mineral resources; development and use of technologies and technological possibilities; and the use of land.
2. Impacts on settings. Consequences include national, regional, and metropolitan development patterns; and effects on environmental quality, including air and water pollution emissions, noise, and aesthetic values.
3. Impacts on people. Consequences include effects on personal mobility and accessibility; effects on life-styles, values, and family structures; effects on employability, personal income, and wealth distributions across different social groups; effects on recreational patterns; and consequences having to do with personal safety and security.
4. Impacts on institutions. Consequences deal with governmental and other political roles--at national, state, and local levels--in areas of promotion and regulation/control; effects on social service delivery systems, such as health care, communications, waste removal, and social welfare; effects on private and public suppliers of transportation equipment, facilities, and services; and effects on organized labor, and on industry and trade organizations.

Consequences in all of the above categories are not identified for every technology option; however, these categories are utilized to direct an orderly search for as many significant consequences as possible. Certain impacts turn out to overlap more than one category, and often a chain of consequences will involve indirect effects and feedbacks involving several and sometimes all categories.

Stages of Technology Delivery. A search is also made for consequences that may occur during the different stages of technology delivery. This search builds on the paradigm for technology implementation developed in Volume 2. The nature of transportation technology delivery is such that important impacts can occur in each of the following stages in a technology's life cycle:

1. Invention, promotion, and development
2. Implementation, involving capital investment, and construction
3. Operation
4. Revision, replacement, or abandonment

Timing. Another critical consideration is the timing with which consequences occur and are perceived. Certain impacts, such as noise intrusion from a new facility, occur early and generally remain. Some impacts may occur early but may not be perceived as important for some time; for example, the gradual build-up of concern about automobile-caused air pollution. Some impacts may eventually disappear due to the workings of other processes such as labor dislocations being ameliorated eventually through retraining and other adjustments in the labor pool. Other impacts may gradually develop and accumulate; for example, the combined changes in urban transportation, consumption patterns, and retail merchandising that gave rise to the supermarket as a substitute for the corner store.

Settings Influence Impacts; Impacts Influence Settings. A major concern in this analysis is the importance of establishing the conditions under which impacts of technologies may develop. Background settings--geographical development patterns, social and political beliefs, economic regulatory conditions, and so on--clearly influence the chains of consequences that can occur; furthermore, the consequences themselves often react to help bring about significant changes in the original settings. Both effects are of major consequence in this technology assessment.

As a procedural tool, the background scenarios developed in this study, documented in Volume 4, were employed to discipline the types of "what if?" questions asked about the settings in which transportation technologies might evolve. The procedure was, first, to articulate the nature of an impact as it might develop under its most conducive background setting; then, a series of questions are asked concerning how the impact might vary if different background settings are assumed. Finally, questions are asked concerning whether the impacts identified would likely cause changes in the settings themselves, and under what conditions such changes might occur.

In addition to the background scenarios, four additional transportation demand-related settings are identified. That is, the impacts of technologies are considered relative to their occurrence in:

- Short-range/low density settings (e.g., Elko-Ely, Nevada)
- Short-range/high density settings (e.g., New York-Philadelphia)

- Long-range/low density settings (e.g., Harrisburg, Pa.-Boise, Idaho)
- Long-range/high density settings (e.g., New York-Los Angeles)

These demand-related settings arise from a cross classification of (1) distances between places, divided into short range and long range; and (2) the number and spatial distribution of people to be served, divided into low density and high density. Special cases of the short-range, high density setting occur in major corridors, such as Boston-New York-Washington.

Actions to Impacts; Impacts to Actions. The final formal consideration of the analysis deals with the feedback interrelationships between transportation technology impacts and the political, institutional, and individual actions taken in response to these impacts. For example, the high cost of a tracked levitated vehicle (TLV) system might stimulate government action to restrict air competition, leading to reduced service to many travelers and eventual business and residential relocation, further eroding the financial condition of the TVL system. Such cycles (containing an impact, followed by related actions, followed by second order impacts, followed by other actions) are traced out as far as seems meaningful.

### Presentation

Impacts Within and Across Technologies. During the impact analysis process, it became clear that it is not always convenient to relate an impact to a single family of technologies, but, rather, certain impacts are described more efficiently with respect to groupings of technologies. Similarly, still other impacts are described more efficiently with respect to generic features of transportation technologies. Consequently, impacts are documented in two main chapters, in which impacts are described, relative to:

- particular technologies
- issues that cut across groups of technologies

In the latter chapter (Chapter IV), impacts are identified both in connection with groups of technologies and in connection with certain generic features of technologies.

Illustrations. The method of documenting impacts is intended to relate closely to the evaluation methodology described above. To illustrate this connection, impact descriptions are labeled by grids identifying the categories of impact and the stages of technology delivery with which they are associated. Each impact grid is of the following form:

	Promotion	Planning	Implementation	Operation	Revision
Resources					
Settings					
People					
Institutions					

	Promotion	Planning	Implementation	Operation	Revision
Resources					
Settings					
People					
Institutions			●	●	

For example, the figure appearing at the left indicates a discussion concerning impacts on institutions that occur during both the implementation and operation of a particular transportation technology.

Many impact discussions are accompanied by an illustrated chain of consequences. Each illustration is a summary of the discussion in the adjacent text. In addition to highlighting the major points in the text, these illustrations describe some of the more complex feedbacks and other interrelationships among impacts and actions that are not easily described in the text.

## II. EXPECTED IMPACTS OF PARTICULAR TECHNOLOGIES

### Small CTOL Aircraft

	Planning	Implementation	Operation	Extension
Resources	●			
Settings				
People				
Institutions	●	●		

Low density feeder service is inherently more costly than high density line haul. (See "Technological Forms of Intercity Transportation" in Volume 2.) Unconstrained by regulation, airlines will generally tend to acquire and use aircraft types that most profitably exploit their high density route segments, even while increasing losses on low density segments. This adds to the motivation to shed the low density unprofitable routes and reduce internal cross subsidies. Thus, under relaxed regulation, major airlines tend to abandon low density markets, seemingly leaving opportunities for new operators with smaller equipment to enter these markets. The existence of suitable small aircraft that have improved cost characteristics, use medium length (about 4,000 feet) runways, and are reliable and easily maintained, would be expected to attract new firms to low density air markets and aid their financial performance. However, the demand for low density service, particularly in short-range settings, is uncertain, which indicates that the market for new small commercial aircraft is poorly identified and risky. Even if a profitable market in fact comes to exist, this uncertainty would discourage manufacturers from investing in development and tooling to market small commercial CTOL aircraft. On the other hand, a more well-identified market for small commercial aircraft might exist under a different scenario of government regulatory support of internal cross subsidy in commercial air transportation, regardless of the economic justification for such action. Under this scenario, in which major airlines are required to provide service in low density routes, the need to standardize equipment to serve both high and low density routes encourages the use of higher than optimum capacity aircraft on low density routes, increasing their losses while reducing the potential market for new small aircraft. Given political pressure for low density service, this scenario seems likely to lead to the need for public subsidy and a continuing cycle involving increased government control over operations, more low density routes, higher losses, more subsidy, more government control, and so on.

	Planning	Implementation	Operation	Extension
Resources				
Settings			●	
People				
Institutions				

Successful introduction of new small CTOL aircraft would be expected to enhance the position of small and medium-size communities in competing against the larger urban centers for economic development. The magnitude of such enhancement is relatively minor, however, compared to other economic and political factors affecting business and population decentralization, such as federal, state, and local tax policies, housing and social service policies, environmental controls, and so on.

	Planning	Implementation	Operation	Revision
Resources				
Settings				
People			●	●
Institutions				

Major expansion and improvement of commercial air transportation in low density markets might be

expected to reduce the utilization of personal and corporate general aviation aircraft to some extent. Whether this would cause a major slowdown or even a reversal of general aviation activity would be minimized under a strong economic growth scenario, in which the convenience, flexibility, and freedom offered by privately owned aircraft would be valued most highly against their cost.

successful introduction of new small CTOL aircraft

some development of small and medium-size communities

some activity losses in major urban centers

significantly increased feeder operations

reduced general aviation activity

pressure for separate traffic control treatment

performance different from larger aircraft

heterogeneous fleet

airport capacity overtaxed at hubs

construction of new runways & airports (?) in major hub cities

	Planning	Implementation	Operation	Revision
Resources				
Settings				
People	●		●	
Institutions				

Extensive feeder services provided by a new generation of small commercial aircraft could have a significant impact upon crowded hub airports where feeder and line-haul networks join. Pressure could mount for separate treatment in the air traffic control system of feeder operations, particularly if such aircraft have significantly different

operating speeds and maneuverability than the larger aircraft. Unless separate runways can be provided, expanded feeder services could seriously tax existing airport "airside" capacities. While construction of new airports in major metropolitan areas would help, assuming financial and political feasibility, the distribution of traffic among metropolitan airports is not likely to be "rational" enough to completely solve this problem.

### Expanding CTOL Service

	Planning	Implementation	Operation	Revision
Resources				
Settings				
People	●		●	
Institutions				

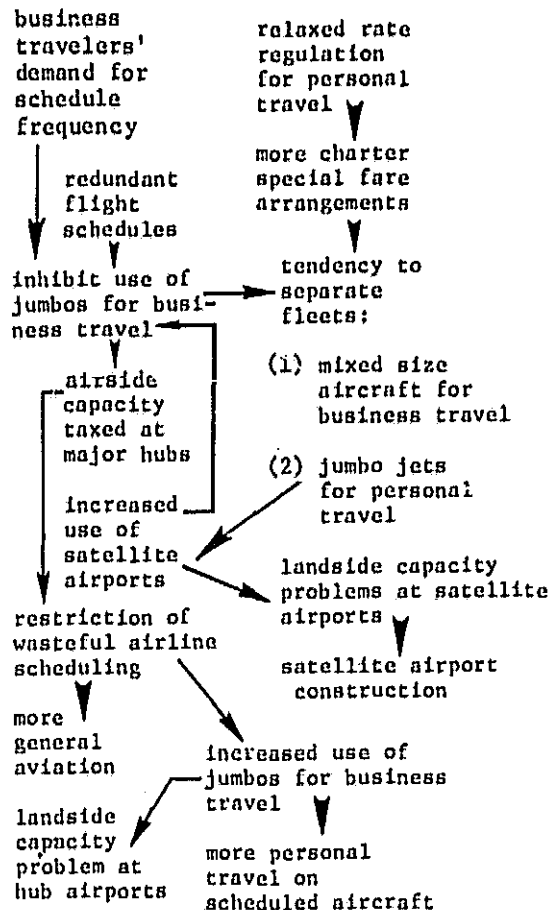
Airside capacity deficiencies at existing airports will not be offset by the increasing use of widebody aircraft to nearly the extent once anticipated. While traffic volumes will continue to increase, a combination of carriers' need to compete for business travel with suitable schedule frequency, plus continuation of the practice of

competing airlines scheduling similar aircraft on the same routes at the same time, will continue to retard conversion to widebodies and to tax airport capacity. Also, to some extent, growing business traffic would be expected to cause increased use of satellite airports, with locally adverse environmental effects, but with possible reduction of pressure on hub airport airside capacity.

	Planning	Implementation	Operation	Revision
Resources			•	
Settings			•	
People		•	•	
Institutions		•	•	

If large aircraft are pressed into service prematurely on many routes in the interests of economy, this could be accompanied

by cutbacks of direct service between many other secondary city pairs, thus encouraging a hub and spoke air route structure. In such a structure, the service between hub cities should improve somewhat and nonhub city pairs service would be reduced considerably (see Volume 4). This situation would probably evolve either in a scenario in which a few large noncompeting airlines dominate in separate regions of the country or in a scenario in which air service is governmentally coordinated. In the former case, the service reductions on many routes might stimulate renewed competition which, if permitted by government, could significantly reduce the profitability of the major carriers. In the latter scenario, the economic growth of nonhub cities would be expected to be impeded somewhat relative to the hubs. Under these conditions, the hub airports would generally experience serious landside capacity problems, made worse by the reduced importance of satellite airports within these urban areas.



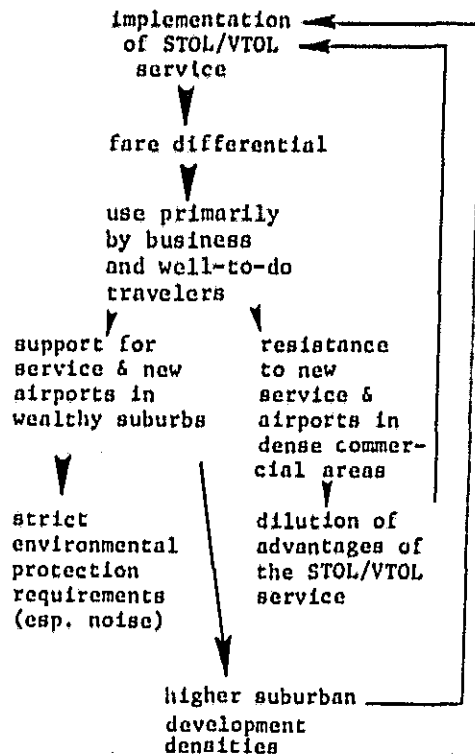
## STOL/VTOL

	Planning	Implementation	Operation	Revision
Resources			•	
Settings			•	
People		•	•	
Institutions		•	•	

Short runway (i.e., less than 3,000 feet) or vertical takeoff and landing aircraft are inherently less economic than CTOL, due to the extra power required for quicker takeoff (see Volume 3). With current technology, for short-range flights, the economic difference becomes small above about 4,000 feet of required runway length.

For short runways, fares, unless subsidized, must be higher than comparable CTOL, suggesting that price-conscious travelers will generally use somewhat less convenient CTOL airports or ground modes. This leaves business and well-to-do travelers to constitute the market for STOL/VTOL services. Under a sufficiently affluent scenario of the future, such travelers might make a sufficiently large market for frequent STOL or VTOL service; however, political acceptance of construction of new close-in airports, if needed to exploit the benefits of such technology, would

be extremely difficult, due to the perceived environmental impacts of both construction and operation and due to the limited constituency for the new service. While promise of increased mobility might possibly justify commercial use of existing airports and even the construction of new airports in affluent residential suburbs, less affluent residents near commercial areas, the destinations of many business trips, would be expected to offer considerable resistance to the environmental intrusion of new airports or the commercial use of existing airports, significantly reducing and perhaps eliminating the comparative service advantages offered by the new technology. The emergence of markets for short or vertical takeoff and landing aircraft will be accelerated in proportion to the overall affluence of the population and the extent to which high income housing exists in patterns that can be served conveniently by satellite airports. Such service, once provided, would contribute somewhat to the further nucleation of urban development patterns, to take better advantage of improved suburban air service.



### An American SST

	Planning	Implementation	Operation	Revision
Resources				
Settings				
People				
Institutions	●			

Environmental impacts, particularly noise and high altitude air pollution and excessive energy consumption, remain strong political arguments against revival of the U.S. SST program. However, assuming that current environmental and economic problems are resolved, through currently unforeseen breakthroughs under a polarized "no growth" political scenario, government involvement in development of even a relatively fuel-efficient and environmentally benign SST could continue to be opposed strongly by interest group litigation.

	Planning	Implementation	Operation	Revision
Resources	●	●		
Settings				
People				
Institutions	●	●		

A formidable barrier to government financial involvement in a renewed U.S. SST development program is the difficulty of obtaining a sufficient measure of popular political support. Under near-term economic conditions, and with current SST performance requiring premium fares, public SST funding would likely be viewed as a subsidy to the rich, and secondary economic benefits (employment increases, etc.)

would not be sufficiently widespread to gain support on this basis. (See "The Congressional Politics of Intercity Transportation," Volume 2.) However, major political barriers to SST development might disappear if the venture could be backed entirely with private capital, which is possible before 2000 under a strong economic growth scenario and with the assistance of government-backed research on related technologies, such as in the B-1 bomber. Success in such a venture could contribute significantly to U.S. prestige and economic position in the world, possibly leading to a renewal of domestic political support for a strong U.S. role as a technological innovator to the world.

	Planning	Implementation	Operation	Revision
Resources			●	
Settings				
People				
Institutions			●	

Successful expansion of economic SST service could significantly stimulate international business travel with dramatic effects upon business and trade practices in many countries. If this occurs at a time when economic and political institutions in developing countries are unprepared for significantly increased internationalism, serious local political and social repercussions might occur. This effect would be most extreme in a vigorous, loosely controlled economic growth scenario. The possible effects of the rapid effective shrinking of the world could be profound, of a magnitude akin to the effects of introducing worldwide jet travel in the 1960s.

### Intercity Bus

	Planning	Implementation	Operation	Revision
Resources			●	
Settings				
People			●	
Institutions			●	

Buses are the lowest cost form of common carrier intercity transportation. However, the prospect of new technologies exploiting the economic and service advantages of the intercity bus appears dim, unless the apparent adverse features of this mode can be overcome. These features include poor coordination with other modes, little service flexibility, and a number of psychological factors such as lack of consumer appeal, unaesthetic terminals, lack of comfort, and in some cases, a perceived security threat from other travelers. Some of these problems may be ameliorated in the future by incorporating improved bus terminals in urban center renewal, by relaxed regulatory practices (see "The Impact of Deregulation" in Volume 2), and by the increased presence of security and law enforcement personnel.

	Planning	Implementation	Operation	Revision
Resources				
Settings			●	
People			●	
Institutions			●	

Improved intercity bus service is a particularly effective means to provide increased mobility and economic opportunity to the disadvantaged. Bus systems provide essential links between rural communities and various health and social services; hence, their improvement would be expected to encourage population dispersal, particularly if employment opportunities continue to move away from large cities (as other considerations suggest they will).

	Planning	Implementation	Operation	Revision
Resources	•	•	•	•
Settings				
People		•		
Institutions			•	

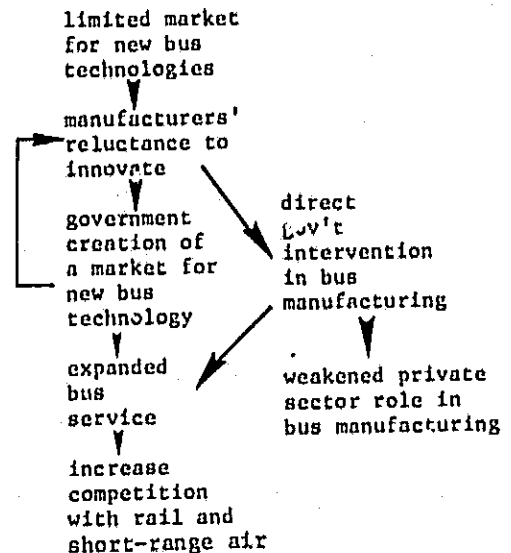
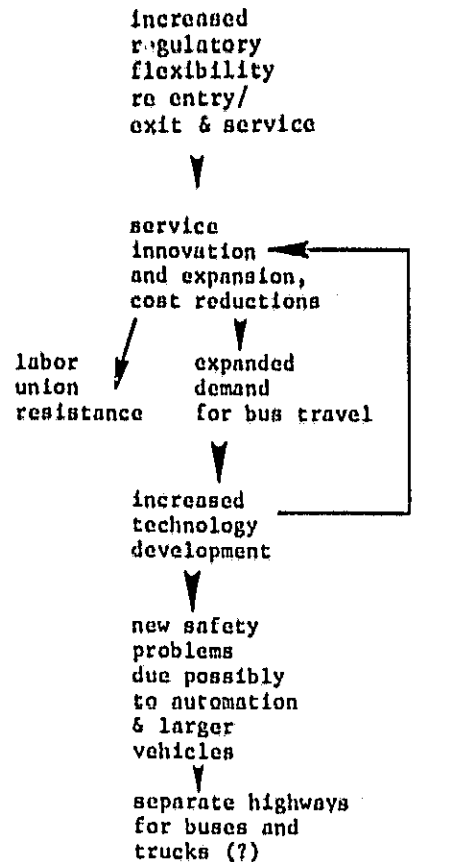
Major near-term improvements in intercity bus transportation would likely be dependent upon regulatory agency willingness to loosen restrictions on market entry/exit and service. Such willingness could encourage innovations such as more express service, better connections with other intercity modes (especially rail and air) and with urban public transport, introduction of different classes of service (e.g., the "grey rabbit"--a cut-rate, rather unreliable transcontinental service), and vehicles with varying amenities (e.g., widebodies). Articulated buses might be introduced to achieve some economies of scale, by reducing labor costs.

Vigorous growth in intercity bus service might help to establish a suitably sized vehicle fleet for early experimentation with automated highways in a few densely traveled intercity corridors. If such experiments are successful, a major opportunity would be created for additional increases in bus labor productivity, for example, using a highway-train of temporarily linked buses with a single driver. Such innovations are not without problems, of course, such as the possible resistance of organized labor, safety considerations (perhaps requiring separate rights-of-way for highway-trains of buses and trucks), and the need for suitably powerful (perhaps detachable) propulsion systems to allow efficient tandem operation and to help ameliorate potential noise impacts.

	Planning	Implementation	Operation	Revision
Resources	•	•	•	•
Settings				
People		•		
Institutions			•	

For technological innovation to occur in intercity bus transportation, its development must be seen as a worthwhile risk by bus manufacturers.

The relatively thin market for such



technology that exists under current service conditions significantly increases this risk. Additionally, lack of competition in domestic bus manufacturing, inflexible regulatory practices, particularly at the state level, and other institutional factors produce an environment in which technological innovation is difficult. (See "Constraints to the Implementation of Intercity Transportation Innovation in Volume 2.) Perhaps innovation could be stimulated by government action to create a larger, lower risk market, for example, to satisfy military needs or in connection with foreign aid. Direct government involvement in bus manufacturing, except to sponsor or perform high-risk component research, would probably just discourage private sector initiative in this industry. Clearly, intercity bus has the potential to compete successfully with both passenger rail and short-range air transport in many markets, and the opportunity is substantial for government involvement to distort the relative perceived costs and hence the market choices among these competing modes.

### Automobile Transportation

	Planning	Implementation	Operation	Revision
Resources	•	•	•	•
Settings	•	•	•	•
People	•	•	•	•
Institutions	•	•	•	•

Automobiles now account for about 85% of intercity and the majority of intracity travel. The speed, convenience, and flexibility of this mode suggest that, in one technological form or another, the personal automobile will most likely be the predominant mode for both intercity and intracity transportation in the foreseeable future. However, future technological improvements, both for environmental protection and cost reduction can be expected to cause significant changes in both the service characteristics and the impacts of this technology. Early transition to a more plentiful fossil fuel (e.g., coal, oil shale) for vehicle propulsion would permit an orderly later evolution to a renewable resource base for automobiles, possibly involving electric power from fusion, sometime after the turn of the century. The leverage in automotive propulsion technology is so great that, for example, a five-year difference in the rate of technological evolution would have a significant effect on total U.S. petroleum consumption through the remainder of the century. Changes in automobile propulsion technology certainly will be a major factor in the eventual attainment of national energy independence and in maintaining favorable fossil fuel prices for all uses.

	Planning	Implementation	Operation	Revision
Resources	•	•	•	•
Settings	•	•	•	•
People	•	•	•	•
Institutions	•	•	•	•

Automobiles have a considerable effect on air quality in many cities. Improvements in automotive propulsion technologies are having a significant positive effect on urban air quality, although there will continue to be an air quality problem in some areas for many years due to the slow retirement of older, "dirty" vehicles and due to nontransportation sources. Elimination of undesirable pollution emissions from new automobiles will be substantial by the mid 1980s. Even further improvements can be expected later, particularly if new engine technologies are implemented. The long-term air quality

improvement achieved through cleaner automobiles will depend upon whether government intervention in the next decade to impose short-term pollution control strategies is consistent with the long-term evolution of substitute technologies with even greater potential for improvement. The possible transition, after 2000, to a renewable and nonpolluting resource base for automobile propulsion, possibly involving electricity, will be affected by government strategies for imposing interim technological solutions.

	Planning	Implementation	Operation	Reversion
Resources				
Settings				
People				
Institutions				

Implementation of non-polluting, energy efficient, moderate cost automobile technology may stimulate a new program of intercity highway

building, providing an excellent opportunity to test innovative improvements to the roles of vehicles, highways, and drivers. Demand could develop for power delivery through electrified highways and for vehicle guidance through automated highways. Transition to electrified and automated highways could have significant productivity implications for bus and truck transportation.

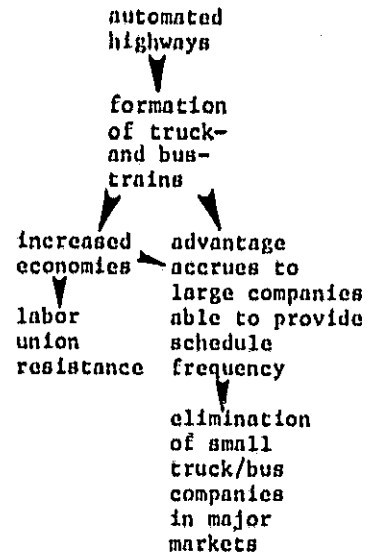
Assuming suitable safety provision, such as full separation of automated and non-automated traffic, automated control could encourage formation of bus- and truck-trains, with strings of, say 2 to 10 powered vehicles dispatched under the responsibility of single drivers.

Organized labor might be expected to resist such laborsaving innovations. However, if highway trains are successfully introduced, savings accruing to large companies able to form trains regularly with good schedule frequency would tend to force small operators, particularly the independent truckers, out of major markets. These latter developments would be most likely to evolve in a permissive regulatory, productivity-oriented environment.

	Planning	Implementation	Operation	Reversion
Resources				
Settings				
People				
Institutions				

Introduction of a new automobile propulsion would require gradual conversion of service stations to handle the needed new types of fuel. This raises a question about the late transition period when, due to the decreasing availability of gasoline on the open road, the last of the old gasoline-powered internal combustion autos might

become primarily urban vehicles, owned by the urban poor. Through their growing obsolescence, ownership of these vehicles could restrict accessibility to recreational and other opportunities available beyond the immediate urban area.



	Planning	Implementation	Operation	Revision
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People				
Institutions				

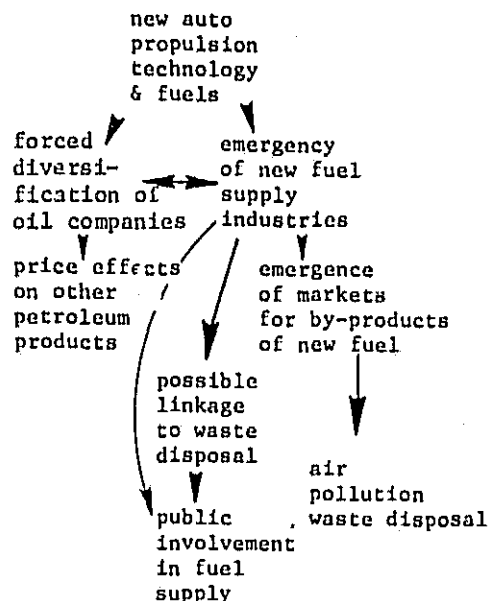
Service and maintenance facilities for the automobile of the future may experience some difficulty adapting to new propulsion technologies. As an extreme example, service stations to support a fleet of electric autos would probably require considerable investment in battery handling and changing equipment and, more significantly, in space to store a large and potentially costly inventory of replacement batteries. Storage tanks and pumps to handle substitute liquid fuels for future engines could be costly and difficult to fit into existing service station layouts, particularly during the lengthy transition period when both gasoline and substitute fuels must be kept in stock.

	Planning	Implementation	Operation	Revision
Resources				
Settings				
People				
Institutions				

Transition to new automobile propulsion technologies could significantly affect the employment of individuals now engaged in vehicle service and maintenance. Substantial retraining of mechanics would be required to deal with new engine technologies and some mechanics may be unable to adjust as their former skills become obsolete. Even more widespread skills obsolescence would be expected to accompany transitions to electric and automated highway vehicles. New skills would be needed not only in vehicle maintenance and service, but also in highway construction and maintenance, where civil and materials engineers may partially be superseded by electrical and mechanical engineers. These effects may largely be ameliorated under scenarios containing strong job security labor contracts, thereby retarding introduction of the new technologies, or in the presence of vigorous union-supported, industry-supported, or government-supported retraining programs.

	Planning	Implementation	Operation	Revision
Resources				
Settings				
People				
Institutions				

Transition to nonpetroleum propulsion sources for the automobile would have a significant influence on the fuel supply industry as well as on international trade and foreign policy. The extent to which existing oil companies would be able and willing to convert to supplying liquid methane, methanol, or another alternate fuel; the extent to which domestic and foreign competitors, perhaps including public or private waste disposal industries, would enter the market; each organization's ability to make capital investments during the critical transition period; and the impacts upon the prices and services offered domestically and internationally by these organizations in companion product areas are all now unknown but may be potentially significant factors to be considered before implementing a new automobile technology.



	Planning	Implementation	Operation	Revision
Resources	•	•	•	•
Settings				
People				
Institutions	•	•	•	•

Eventual transition to electric autos might not produce a large energy savings over alternative propulsion technologies, but it could provide the opportunity to utilize energy based on consumption of renewable or virtually limitless resources (e.g., in 25 to 50 years, solar, geothermal, tidal, and nuclear fusion technologies may be in widespread use). The capital cost of implementing electric auto technology would be enormous, in part due to additional electricity generation and transmission facilities. If autos are adapted to receive power directly from highways, this increases capital demands for highway construction and retrofit and adds to the duration and height of peak electricity demand, further increasing the need for generating capacity and means of storing off-peak power for peak period use. Electrification of highway travel could occur on a widespread basis only after the relative cost of electricity generation and transmission compared to other power sources decreases beyond that of today. To some extent, the economic advantage of electricity generation will depend upon the perceived importance of the environmental costs of alternate power sources. Under these conditions, automobile electrification may actually help industry exploit economies of scale in future electricity technologies, and, in the long term, hopefully reduce electricity rates to all users. However, this price effect could go either way, depending upon the rate of introduction of electric autos relative to the rate of electrical generating capacity expansion and the nature of the electric power generation and storage technologies that are implemented.

advances in electrification technology

introduction of electric automobiles

increased capital investment in electrification

power pickup from highways

increased demand for electricity

price effects(?)

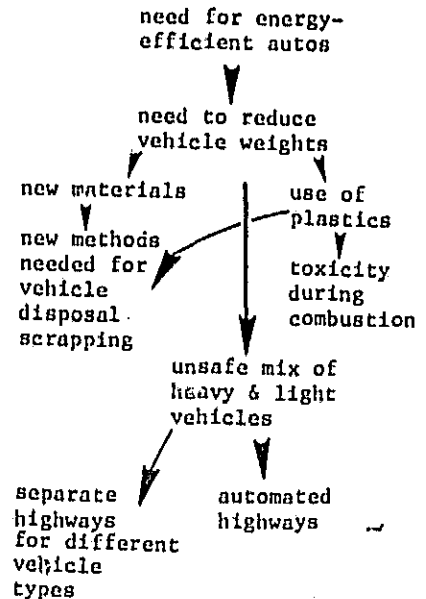
	Planning	Implementation	Operation	Revision
Resources	•	•	•	•
Settings				
People	•	•	•	•
Institutions				

The net effect on natural resource use of widespread electrification of intercity transportation and particularly highways is uncertain. Furthermore, the picture will probably become even more complex in the future due to the emergence of other commercially viable auto engine technologies. While, in the 25- to 50-year time horizon, costs of electricity generation and transmission may decrease relative to other power options, there are a number of possible direct and indirect problems associated with electrification, such as higher prices for necessary metals, including copper and aluminum; considerable disruption to highway users and surrounding communities during construction; the vulnerability of the system and its users to power failure, and military or terrorist attack; pilferage of power and valuable metal parts; and vulnerability to snow, ice, and other debris. Use of synthetic fuels, on the other hand, may be less energy-efficient, more polluting, and involve higher purchase and maintenance costs to users

due to the greater complexity of combustion engines, relative to electric motors.

	Planning	Implementation	Operation	Revision
Resources				
Settings				
People				
Institutions				

Emphasis on energy efficiency may lead to long-term efforts to reduce automobile weight, raising the need for suitable lightweight materials and components. If plastics are used extensively, questions arise concerning: the price stability and availability of petrochemicals for their manufacture, the availability of methods for reducing old cars to marketable scrap, and the toxicity of fumes released by plastics during auto combustion due both to scrapping and accidents. Increased safety problems may be anticipated in collisions of light vehicles with the older, heavier autos, and with trucks and buses. This suggests the possibility of separate highways for light vehicles, which would be achieved, of course, only with large implementation costs and significant environmental impacts. A possibly more economical alternative to separate highways is the automation of existing highways to increase safety and achieve other benefits. However, the safety problems that could occur during the transition to automation are themselves potentially serious enough to warrant considerable attention.



	Planning	Implementation	Operation	Revision
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People				
Institutions				

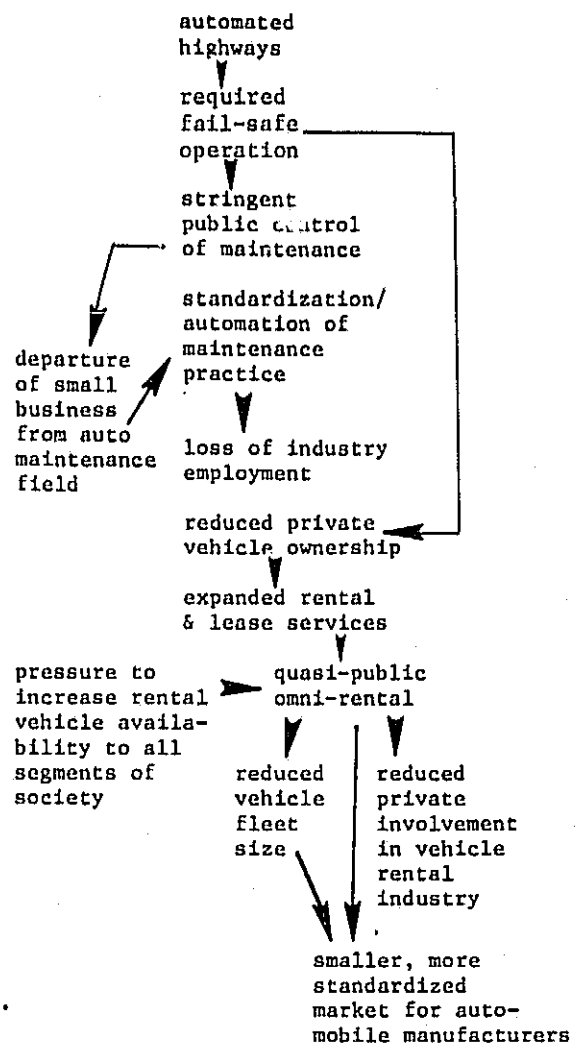
Major technological improvements to the highway system will require new funding mechanisms. (See "The Cost-Revenue Squeeze in Highway Finance," in Volume 2). One possibility is to tie funding for electric and eventually automated highways to an electricity use tax (assuming that electrification is likely to precede automation). This raises questions concerning the proper formula for allocating receipts among transportation and other uses. One problem with automatic, continuing, special-purpose funding mechanisms, like the present gas tax trust fund, is that they create substantial momentum for spending and develop a sizable dependent constituency of public employees and private contractors. Unless new funding mechanisms are designed to run down eventually of their own accord, there exists a long-term potential for making economically inefficient public investments, just because the funds are available. Thus, the opportunity to spend these funds for alternate, and increasingly useful purposes is foregone. An alternate funding option involves the use of computerized vehicle sensing equipment to tally up and issue billing for each vehicle's use of electrified highways. The implications of such a surveillance system for individual privacy is of serious concern.

	Planning	Implementation	Operation	Revision
Resources		●		
Settings				
People		●		
Institutions				

The electrification and automation of existing rural highways, while less expensive than building complete new facilities, could give rise to significant implementation costs, inconvenience, and reduced safety. To avoid the extra costs and hazards of mixing the new technology vehicles with vehicles not under automatic guidance (some guidance generally being required for electrified highways to ensure maintenance of electric contact), electrified/automated and non-electrified vehicles may have to be separated by physical barriers. Except on the limited portion of the intercity highway system having more than four lanes, it is doubtful that an electrified/automated lane could be added without significantly widening rights-of-way, bridges, etc. Traveler delays and hazards incurred during major reconstruction are, of course, important impacts of such undertakings.

	Planning	Implementation	Operation	Revision
Resources		●		
Settings				
People		●		
Institutions		●		

Strict maintenance standards would have to be enforced for "dual-mode" vehicles that can operate on or off automatic highways. Since responsibility for safety would be borne primarily by equipment, the need to assure fail-safe equipment operation might lead to increased public control of vehicle maintenance practice. The added administrative and reporting costs of public control might discourage small businesses from remaining in the automobile maintenance and repair field after the introduction of dual-mode highway technology, which might significantly reduce the profitability and vocational appeal of owner/operator service stations and lead to increased fuel company involvement in fuel retailing. Aggregation of the auto maintenance and repair industry could significantly stimulate automation in this field, expanding the use of computer diagnostics, easily substitutable plug-in parts, and the like, which might cause major changes in labor productivity, labor pool size, and labor training requirements. The extent to which auto manufacturers seek and are permitted to own and control vehicle repair and maintenance facilities, and the



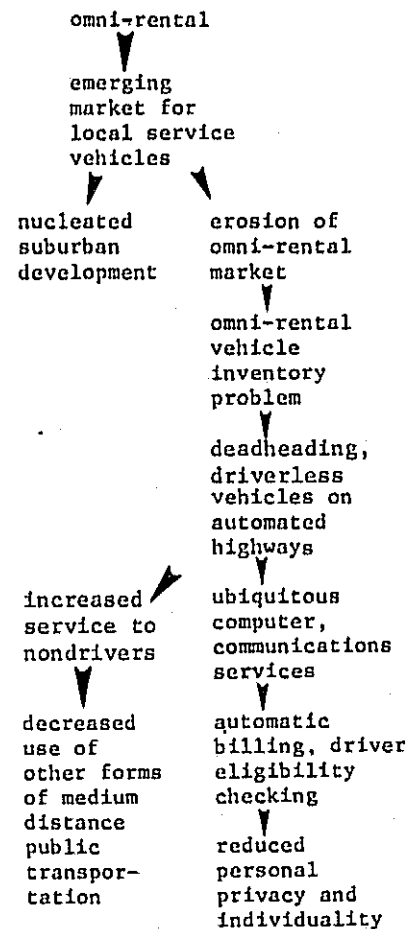
accessibility of capital markets to small businesses will influence the nature and extent of this evolution.

	Planning	Implementation	Operation	Revision
Resources			●	
Settings				
People		●	●	
Institutions		●		

The high liability involved in operating an unfit vehicle on automated highways might discourage private vehicle ownership and lead to significant expansion of vehicle rental and leasing. To ensure that public investments in automated highways benefit all segments of the population, the government might act to broaden public access to dual-mode vehicle rental, leading to the growth of a quasi-public rental service, "omni-rental." Omni-rental vehicles would be stored at a large number of different locations and be available for immediate use by qualified drivers, upon presentation of suitable identification (probably by inserting a magnetic identification card into a vehicle unlocking device). Payment would occur later. The resulting increased sharing of vehicles, coupled with longer auto life due to improved maintenance, could result in a significant reduction in the market of new automobiles. Also, the widespread use of dual-mode autos, supplied only through omni-rental, probably would reduce or eliminate the role of individuality in the marketing and use of personal automobiles. The extent of this effect on manufacturing will, of course, depend upon the rate of growth in demand for mobility, which, in turn, will depend upon economic and life-style trends.

	Planning	Implementation	Operation	Revision
Resources				
Settings			●	
People		●	●	
Institutions		●		

Widespread use of automated highways, employing dual-mode vehicles supplied through omni-rental, might generate demand for separate local-service privately owned vehicles, specifically designed for low-speed intracommunity travel. Increasing popularity of such vehicles would provide an incentive to concentrate personal activities in a smaller area, which would reinforce economic and cultural segregation of suburbs and older urban centers. Such technology would promote the "nucleation" of metropolitan areas giving rise to a pattern of scattered medium-size business, shopping, and entertainment centers, each providing a rich array of goods and services locally, connected by high-speed automated highways and various forms of high-speed public transportation. The low-speed, intracommunity personal vehicles would provide continuing competition to the omni-rental system and could eliminate much of the local market for that service. The superior speed, safety, and convenience



of dual-mode, omni-rental vehicles would probably cause that technology to dominate for medium and long-distance travel. With the emergence of separate fleets of private intracommunity and public omni-rental vehicles, large inventories or considerable deadheading of the omni-rental vehicles would be needed. Reliance on deadheading to reduce omni-rental vehicle inventories would require vehicle routing and scheduling practice, and might involve the development of technology to handle driverless dual-mode vehicles on automated highways. This development would provide an opportunity to extend the services of the dual-mode technology to nondrivers (the very old, young, and handicapped). Such a system might eventually replace the other forms of public transportation for many medium length (15- to 150-mile) trips. For this type of system to be safe and effective, it would require elaborate and reliable electronic instrumentation, perhaps involving centralized computerization. A logical extension of centralized computerization would be automatic access to individuals' eligibility records to eliminate omni-rental check-out delays and to facilitate billing. The implications for personal privacy and individuality in the presence of such a centralized record-keeping system are not attractive. The emergence of omni-rental as a form of public transportation utility, as described above, would probably not occur in isolation, but would occur as part of an expanding web of computerized social services, enabled by rapidly increasing productivity in information transmission and manipulation technologies.

	Planning	Implementation	Operation	Revision
Resources			●	
Settings			●	
People				
Institutions				

Technological developments that increase the speed and convenience of long-distance travel by automobile, such as automated highways and auto-train, would be likely to increase recreational use pressures in remote areas of the country. For example, automation of Interstate 5 from San Diego to Seattle, with 120-mph speed, would bring large numbers of Californians to within convenient striking distance of currently remote areas in Oregon and Washington. Such mass movements of large numbers of vehicles and their occupants to remote mountain and desert areas would probably be perceived as an immediate economic benefit to these places, and also as an environmental dis-benefit. However, increased dependence of rural communities on seasonal recreational spending could prove detrimental to their economic and cultural well-being in the long term.

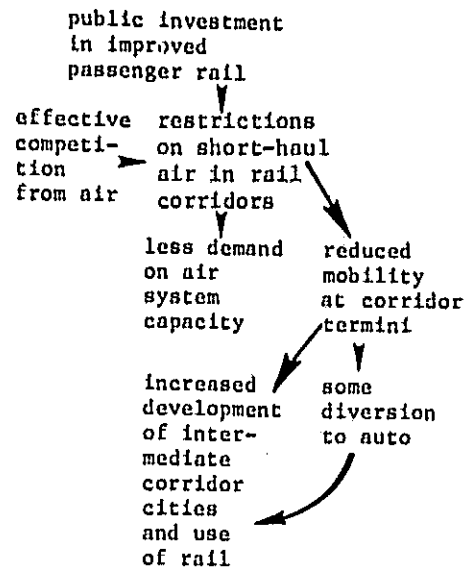
	Planning	Implementation	Operation	Revision
Resources				
Settings			●	
People				
Institutions				

The spread of electrified and, particularly, automated highways could significantly affect those communities that exist primarily to provide service to adjacent interstate highways. Vehicles operating on electric highways require few, if any, service stops; passengers in automated vehicles at higher speeds would be likely to stop less frequently than today, partially due to opportunities to rearrange vehicle interiors for more comfort and more en route diversion.

## Improved Passenger Trains (IPT)

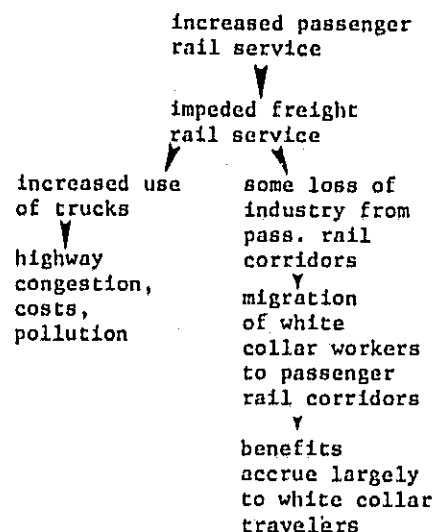
	Planning	Investment	Operation	Revision
Resources		●		
Settings		●		
People			●	
Institutions	●			

Improved passenger rail service in short-haul, high density corridors can be made to compete effectively with air (as demonstrated by the Metroliner). Under a scenario of strong government involvement in intercity transportation, attempts to promote rail travel might lead to public restrictions on short-haul air service in corridors where heavy public investment in rail provides good alternative service. In this situation, some former air travelers would probably switch to rail as their next best option, with others, perhaps the majority, switching to private automobiles. Demands on the air traffic control system and on airport capacity would be reduced by these restrictions. Travelers would suffer some loss of mobility, perhaps significant losses in certain cases. Economic and population growth at intermediate stops along the improved rail corridor could be significant, with further stimulation to rail use throughout the corridor.



	Planning	Investment	Operation	Revision
Resources				
Settings			●	
People			●	
Institutions			●	

Expanded and improved intercity passenger rail service, operating at speeds up to 120 mph might interfere with rail freight operations to the detriment of both the rail freight industry and rail freight customers in affected corridors. Some departure of rail-dependent industry from busy passenger rail corridors might result; or such industries might make greater use of trucking, increasing traffic, maintenance, and environmental problems on corridor highways. Over the long term, the attraction of passenger rail for business travel up to about 250 miles would be expected to increase the proportion of white collar workers that reside in, and benefit from, the improved passenger rail corridor. This relocation effect



would be greatest in scenarios with high density housing growth and high highway travel costs.

	Planning	Implementation	Operation	Revision
Resources			●	
Settings				
People				
Institutions		●		

Strong public support for improved intercity rail would be expected to give rail a market advantage in high density corridors relative to intercity bus. (An argument might be made that the interstate highway program has given intercity bus such an advantage over passenger rail in the past.) Depending upon the extent of rail improvement, short-haul air transport might also be affected significantly. Depending upon the extent of the program, public IPT investment might discourage private sector innovation and investment in these competing modes.

### Very High-Speed Ground Transportation (VHSGT)

	Planning	Implementation	Operation	Revision
Resources		●		
Settings				
People		●		
Institutions				

An important impact of VHSGT is the potentially severe community disruption that would occur during system construction. Assuming the use of low-cost construction techniques, the noise, dust, and travel pattern disruptions that would occur during the several years of system construction could materially affect the land values and the character of neighborhoods through which the system would pass. Severe curvature constraints required for very high-speed operation would make it difficult to be very selective concerning where these impacts would occur. All types of neighborhoods in an urban area probably would be touched to some extent. In a scenario with strong neighborhood citizen action groups and consensus-oriented politics, it is difficult to see VHSGT being implemented. Adverse community resistance might be overcome if the system could be fully tunneled, an enormously costly alternative with current technology.

	Planning	Implementation	Operation	Revision
Resources				
Settings				
People		●		
Institutions	●	●		

Efforts to develop VHSGT guideways in urban areas could generate local opposition in excess of that recently faced by interstate highway construction, since the new system would be of questionable benefit to most traversed communities, due to large distances between stations. Also, some opposition may be based on the premise that the system would primarily benefit the rich. Both opposing viewpoints may be reduced somewhat if VHSGT development is pursued as part of a package of public services (transportation-related or not) with broadly incident benefits. This might be possible under a scenario of effective goal-oriented planning and decision-making and with increasing national wealth.

	Planning	Implementation	Operation	Revision
Resources			●	
Settings			●	
People				
Institutions				

A major difficulty with VHSGT technology is high operating costs, in both the economic and environmental sense. Energy requirements for high-speed operation are high, regardless of whether that operation is in the air or on the ground, and the potential noise impact is significant. On the other hand, ground systems are likely to be

electrified, and thus, operating costs might be reduced in relative terms by future technological breakthroughs in electricity generation by nuclear fusion, solar power, etc. Noise pollution and safety threats from vandalism or accident obstructions in the guideway may be cured by fully enclosing the guideway, which would probably be evacuated to reduce air resistance, and reduce energy consumption. This solution requires the development of strong, lightweight, sound absorbing materials or much more economical tunneling techniques.

	Planning	Implementation	Operation	Revision
Resources		•		
Settings				
People				
Institutions		•	•	

Very high-speed ground transportation systems, such as Mag-Lev vehicles with cruising speeds of several hundred miles per hour, suffer from the fact that with increased cruising speed, average trip speeds become extremely sensitive to the frequency of stops. However, maintaining large distances between stations to increase average trip speed restricts the system's accessibility to many potential travelers in the corridor and thus, reduces demand. Also, unlike in air transportation, there are minimal cost savings to be realized by increasing spacing between terminals, since most of the construction and maintenance costs of ground systems are to provide the guideway (see Volume 3). Such considerations suggest that very high-speed ground systems must be designed using network configurations that permit stations to be bypassed according to the prevailing pattern of demand. Perhaps this can be achieved through joint use of a very high-speed main line by vehicles that operate in express service between different intrametropolitan sub-networks, each sub-network containing a number of downtown and suburban stations. Another possibility is the "moving rendezvous" technique, in which the very high-speed line-haul vehicles never stop, but rather serve as moving transfer terminals that perform successive high-speed rendezvous with the intrametropolitan sub-network vehicles which pick up and discharge passengers at a number of locations within each urban area. While the need for such elaborate networks seems to follow from the nature of high-speed ground transportation, there are significant problems with respect to their operating and economic feasibility.

	Planning	Implementation	Operation	Revision
Resources				•
Settings				
People				
Institutions			•	

Failure of an in-place VHS GT system, due to technical, economic, financial, environmental or other causes, while possibly being detrimental to high-speed fixed guideway transportation innovation for years to come, might enhance the opportunity to innovate in a less exotic manner. For example, the right-of-way of a defunct VHS GT system might be adapted for a high-speed passenger train, although major reconstruction of bridges and tunnels might render this option infeasible. Another possibility would be to use the right-of-way as an experimental automated highway.

### III. ACROSS-MODE IMPACTS

#### Impacts Associated with Groups of Technologies

	Planning	Investment	Operation	Retire
Resources	●			
Settings				
People				
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Over the next 25 to 50 years, the economic growth to be expected under virtually all credible scenarios provides sufficient economic resources to support a large variety of technological innovations in intercity transportation. Whether the wealth is available is not the overriding question; whether particular transportation technologies represent the best private or public opportunities for investment of available resources is. High capital cost options, such as VHSST, the SST, highway electrification, and/or automation, are admissible in the long term if their cost savings and/or service improvements are sufficient to attract public or private funds from alternative investments. Consequently, the costs of developing, acquiring, and operating technologies alone do not dictate their potential for implementation in the long run. Rather, the relationship between the costs and the benefits of a new technology is the main determinant of its potential for implementation. Thus, society's perception of the values of different classes of benefits and the mechanics of the related public, private or public/private decision process will determine which technologies become implemented.

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A number of feasible technology development prospects in intercity transportation raise serious concerns regarding noise impacts. New high-speed ground transportation service, through IPT or VHSST technologies, threatens to be noisy on several counts (power plants, aerodynamics) and technological solutions are not obvious. Some otherwise very attractive new automobile power plants may have noise problems; and a return to higher highway speeds when energy and safety restraints are overcome will occasion more power plant, aerodynamic, and tire noise. Finally, future air travel growth will increase noise, although this effect will probably be more than counteracted by new noise reduction technology. New materials and construction methods required to reduce transportation vehicle noise may, in turn, create their own problems of high capital and operating costs, resource shortages, and material recyclability. Reduced safety due to noise reduction measures may also be of concern, such as power reductions at critical points in aircraft operation and the toxic substances that may be given off by noise suppressant materials during accidental combustion. While noise problems will increase with more mobility, the seriousness of these problems will vary with society's willingness and ability to shape land use to ameliorate this problem, and with the particular political importance of noise pollution. Noise itself encourages population dispersal and lower development densities.

	Planning	Implementation	Operation	Revision
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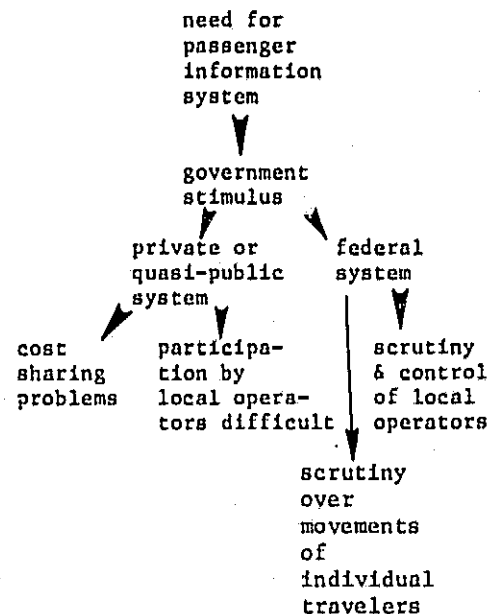
A variety of other environmental questions are of concern in connection with new transportation power sources. Petroleum-substitute fuels for automobiles and aircraft must come from large-scale resource transformation processes, such as coal, gassification or electrolysis, with environmental effects potentially as significant as the pumping, transport, and refining of crude oil. Widespread electrification of intercity transportation (rail and highway, specifically) may require significant additional electricity-generating capability, with a variety of possible heat, emissions, safety, and residue pollution problems (especially atomic wastes) created at the generating facilities.

	Planning	Implementation	Operation	Revision
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Among means of coming to grips with inefficiency in access/egress and intermodal transfers is the proposal to require, by regulation, that such local services be priced as an inseparable part of the total door-to-door trip. The profusion of relevant federal, state, and local regulations that would have to be revised to implement this practice suggests infeasibility on legal and political grounds. If implemented, however, this practice would involve charging below cost for access, egress, and transfer services, these losses being subsidized by line-haul profits. This subsidization would naturally reduce the profitability of the line-haul service, possibly to the point of requiring public subsidy to maintain previous service frequency. Such subsidies would cause the private transportation industry (air and bus) to come under increased government control, and, under an antibusiness political scenario, possibly lead to outright nationalization.

	Planning	Implementation	Operation	Revision
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A variety of suggested intercity transportation improvements are dependent upon traveler information systems, particularly to help travelers find their way to and from intercity terminals and between different terminals. Travel agents and carriers now provide such services on a limited basis, but cannot be expected to incur expenses unilaterally, thereby allowing competing enterprises to increase profit. Having government act as a catalyst in the development of a public or quasi-public central passenger information service is one possible way to overcome these institutional difficulties, but establishing equitable formulas for cost sharing would be difficult, and such actions might result in a solution in which the "richest"

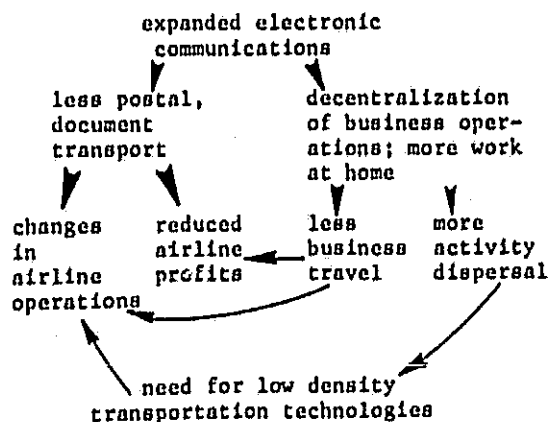


system, i.e., the air carriers, or the government itself, pays for the entire system. The effectiveness of a central passenger information system would, of course, depend upon the accuracy of its data, a formidable problem, since much of the essential information would have to be provided by intraurban public transport operators who could not devote significant resources to the task. Government funding and operation of any information system raises the specter of close federal scrutiny and ultimately operational control of local transport operations. This option could also give government access to computerized itineraries of all travelers (analogous to current airline information system), with undesirable implications for individual freedom and privacy.

	Planning	Implementation	Operation	Revision
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Institutions				

Future regulatory and technological change in electronic communications may lead to significantly expanded telecommunication services from a variety of suppliers:

the phone company, Western Union, various computer firms, even the Postal Service. Growth in services could include increased electronic record-keeping and transmission, electronic mail, shopping via data-phones, widespread document transmission, and so on. Decline of business use of mails, and corresponding airline revenue losses, could be substantial, perhaps leading to changes in airline schedules, routes, and passenger cargo mixes. Businesses might respond to expanded communication services and particularly electronic record-keeping and document transmission by locating sales and office personnel closer to recurrent external business contacts, with less concern for their physical proximity to intracompany colleagues, and less need for business travel. Improved communications would lead to decreased need for concentrating a firm's office activities in a few centralized locations, thus influencing business and residential siting decisions toward choosing more dispersal. A larger number of white collar workers might work in their homes, another force for population dispersal, which would provide a stimulus for the development of low density, high quality intercity transportation, such as provided by small CTOL and automated highways.



	Planning	Implementation	Operation	Revision
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Government efforts to stimulate energy-efficient, non-polluting transportation technologies could hasten the development of, for example, a low-polluting, efficient, synthetic fuel-burning automobile, with costs as low or lower than the internal combustion engine, the latter having been made relatively more costly to satisfy tighter emissions and fuel economy standards. There are several paths

to such a desirable outcome of varying impact. For example, full government vehicle development, relying on expertise lured away from the private automobile industry, would discourage future innovation in the automobile industry and make it dependent upon government for future technological innovation. Also, there is doubt whether government innovators would be able to pursue refinements in the newly introduced technology as vigorously as private industry, to whom technological refinements means higher profits. The political and legal battles to implement a wholly new publicly developed technology would be extremely difficult, and the financial burden of rapid, government-edicted implementation could force some manufacturers out of business, perhaps leading later to pressure for increased government antimonopoly action and some form of industry nationalization. Nationalization of transportation vehicle manufacturing would probably adversely affect domestic industry productivity and, unless restricted by protectionist trade policies, lead ultimately to market dominance by foreign manufacturers. An alternative path to the development of a desirable new technology has government pursuing a "carrot and stick" approach, gradually squeezing the marketability of undesirable technology through performance controls, surcharges, etc., while offering rewards, such as through the tax system, or through government purchasing policies, to those who would manufacture a desired new technology. This approach, by itself, may get the job done eventually, but relies on a fragmented and, therefore, slower process of new technology research and development, and involves considerable potential for poor coordination among the various elements of the carrot and stick. This may lead to confusion and institutional inertia in response to the confused pattern of government signals. A third path combines the previous two, and has government directly performing high-risk research on potentially high leverage components of the desired new technology. This composite approach also requires careful coordination to avoid the inertia due to confusion that may arise through multifaceted government action.

#### Impacts of Generic Features of Technologies

	Planning	Implementation	Operation	Relaxation
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Despite the preponderance of historical evidence, it is easy to overlook or underestimate the profound influence of transportation technology on regional and metropolitan development patterns. There is little doubt that different transportation technologies can establish conditions conducive to a variety of futures. (It is also true that land use and tax policies, housing, employment, and other social programs also dictate development patterns with more influence in the short run than transportation.) Impacts to be expected for different generic technology types are as follows:

- High-speed, high volume transportation systems with few termini (VHSGT, large CTOL, SST) encourage major urban center growth with intraurban patterns dictated by the nature of the metropolitan access/egress system.

- High-speed, low- to medium-volume systems with several scattered stops (small CTOL, STOL/VTOL, bus) encourage nucleated development, with nuclei separation determined by system speed.
- High-speed systems that provide service between any two locations in a service area (automated highway, improved automobiles) encourage low density sprawl, with the extent of sprawl determined by system speed.

Even though improved transportation generally facilitates economic growth, the development trends favored by technologies are invariably accompanied by development losses in places that lose comparative locational advantage through the introduction of a new technology.

	Planning	Implementation	Operation	Reversion
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Low cost, high frequency, easily accessible transportation technologies--such as automated and faster highways and, to some extent, improved rail--might encourage further population and activity dispersion away from major urban centers, beyond existing suburbs to more distant communities, which might allow close-in older suburbs to become economically more available to low income individuals. While such dispersion might result in improved housing availability for the urban poor, social stratification by income class might increase, pressure for development of agricultural and open space land would grow, and efforts to improve urban government efficiency through increased regionalism could be thwarted. Older, close-in suburbs could develop tax base problems, with deleterious effects on social services. Delivery of social services to a more dispersed population would probably be more difficult to organize, but whether the overall effectiveness of social service delivery would be improved or reduced by dispersal is not clear. The nature of these regional development effects would be conditioned by the nature of existing land use controls, and dispersal would be most pronounced in a scenario with minimal land use controls and a wide income difference between rich and poor.

	Planning	Implementation	Operation	Reversion
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One hazard in implementing expensive, high capacity technologies is the potential cost and disruption that would occur if public funding should be reduced before the planned system is fully developed. Certain technologies--such as automated highways, improved rail, evolutionary auto, bus, and conventional air--are incremental by nature and therefore relatively unharmed by fluctuations in public financing. Others--such as VHSCT, SST, and multimodal terminals--must be supported by many years of spending before significant benefits begin to flow, and thus a sudden funding reduction can seriously harm their development. The severity of funding uncertainties can be reduced if recognized and dealt with in the technology implementation plan.

	Planning	Implementation	Operation	Revision
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It is to be expected that early versions of a new transportation technology will require some retrofit as the technology matures and spreads to many locations. The potential expense and disruption of effecting retrofit improvements on technologies with close design tolerances, such as VHSCT and some automated highway concepts, could present serious barriers to their eventual full deployment. For any technology, the economic losses incurred due to nonmodifiability are diminished in relation to the rate of economic growth, with rapid obsolescence possibly even being perceived by business as desirable in a scenario with high economic growth.

	Planning	Implementation	Operation	Revision
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Some transportation technologies--such as improved rail, VHSCT, evolutionary bus, and passenger information systems--may be seen as producing significant indirect social benefits, through, for example, energy savings, environmental protection, preservation of traditional urban centers, or even income redistribution. Consequently, government may decide to subsidize development of such technologies. On the other hand, public outlays to implement such systems in the absence of a generally accepted rationale for continuing operating subsidies may lead to their eventual financial strangulation, giving rise to a significant abandonment cost. This problem is particularly serious in a pro-economic growth scenario in which government transportation expenditures are applied to narrowly defined objectives.

	Planning	Implementation	Operation	Revision
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There may also be problems hidden in the relationship existing between the nature of certain intercity transportation technologies and the research, development, and promotional institutions with which they are related. Certain technologies--primarily highway-related--are much more able to internalize their R&D and capital costs than others, such as VHSCT and passenger rail. As a result, public agencies are more involved in the evaluation of the latter class of technologies than in the evaluation of the former. This can lead to unbalanced government promotion of the latter "public commodity" technologies and technology components, unless this tendency is offset by development of balanced public sector understanding of the overall system and by suitable institutional arrangements at all levels of government to insulate technology promotion activities from research, development, and capital investment activities.

	Planning	Implementation	Operation	Revision
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A consideration in the development of intercity transportation technologies is their implications for foreign trade and the U.S. balance of payments. Different technologies imply different foreign markets. Productivity improvements in conventional aircraft, an American SST, and cost and environmental improvements to automobiles, such as from development of efficient nonpetroleum-fueled engines, would probably find worldwide markets. Small, easily maintained, economical aircraft would probably be more attractive to the developing

countries than to the industrialized ones. Technologies requiring large, specialized infrastructure development, such as electric and automated highways and very high-speed ground transportation, would probably have limited export potential as whole systems; however, various components of these technologies might find many uses, both abroad and in this country. The foreign environmental and economic impacts of certain technologies, such as the SST and the small CTOL, could be more significant than the domestic implications.

#### IV. CLOSING

This report has presented a large number of possible direct and indirect consequences of technological developments that may occur in intercity transportation during the next 25 to 50 years. Some of these impacts are well understood and are seen as likely; others are only hazily perceived and their likelihood is questionable. It is important, however, that all such impacts be identified and mulled over as early as possible in order that future decisions concerning intercity transportation research and technology, as well as those concerning intercity transportation finance, regulation, and policy be made with as much awareness as possible of the long-term implications that today's decisions may impact.

The material in this report is seen as the beginning of what should be a continuing or, at least, an intermittent program in technology assessment concerning the future of intercity transportation. Many of this report's paths of inquiry were probably not pursued far enough; similarly, the passing of time and the accumulation of knowledge will create new insights that will make the results of today's technology assessment change, perhaps significantly, within a relatively short time. As evidence, the rapid changes in political and economic conditions in the U.S. and elsewhere that have occurred during this study cause many factors affecting intercity transportation to be perceived quite differently now than when the study began, one year ago. For example, in the past twelve months, national concern over the possible imminent exhaustion of oil supplies has lessened, apparently reversing a short-lived trend to smaller cars, "no growth" as a feasible economic alternative appears to have been forgotten, and a significant national commitment has been made to reorganize and rejuvenate the Eastern railroads.

Therefore, in addition to the particular impacts documented in this report, it seems that the approach to technology assessment of intercity transportation, outlined in the first chapter, is itself an important study project. This approach deserves as much attention as the particular impacts that are described. The methodology, by which the impacts were identified in this study and by which, in future investigations, they can be refined or replaced, provides a systematic and productive way of thinking about the future of intercity transportation and, as such, may well be the most lasting product of the impact evaluation activity of this technology assessment.